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Report to the
Government of the

**PHILIPPINES**

# CADANG CADANG DISEASE OF COCONUT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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# REPORT TO THE GOVERNMENT OF THE PHILIPPINES ON THE CADANG CADANG DISEASE OF COCONUT

By

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Rome 1959

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# I. INTRODUCTION

In accordance with the request of the Government of the Philippines for technical assistance in the investigation of the destructive cadang-cadang disease of coconut, the Food and Agriculture Organization of the United Nations, under its Expanded Technical Assistance Program, appointed Dr. Frank P. McWhorter as Plant Virologist, to advise and assist the Government in the formulation and implementation of a research program designed for determining the cause of the disease, the method of its transmission and other factors relating to its epidemiology, with the aim of devising appropriate control measures. The expert served in the Philippines from 18 March 1958 to 25 April 1959.

While the expert was in Manila, considerable time was devoted to obtaining equipment for study of the cadang-cadang. Some of the equipment came from FAO headquarters in Rome but most was furnished by the Government of the United Kingdom, through the Colombo Plan. Some of the supply problems are discussed in this report.

Dr. McWhorter was preceded by Dr. W.C. Price who served in the Philippines from November 1956 to October 1957. Dr. Price's report, issued as FAO Report No. 850/1, contains full and praiseworthy discussions on the history, literature, general symptoms, distribution, economics and epidemiology of the cadang-cadang disease. The basic and historical data assembled by Dr. Price served as guidance for all the investigations of the disease carried out by the expert in cooperation with the staff of the Guinobatan Experiment Station. In the present report, the general discussion available in Dr. Price's report are not repeated, except in a few cases where newly gathered information necessitates modification of his conclusions. Interpretation of critical symptoms for diagnosing the disease and the requirements for and steps towards control are here presented in some detail.

The expert is most grateful to Mr. Eugenio E. Cruz, Director of the Bureau of Plant Industry for many favors granted during the expert's sojourn in the Philippines, and for his designation of Mr. Julian A. Agati, Chief, Plant Pathology Research Section, as the expert's counterpart. The research work of the expert was facilitated by the friendly cooperation of all the employees of the Guinobatan Experiment Station, which is in the center of the cadang-cadang devastated area. The competent research workers of the Station have been faithfully carrying out studies on cadang-cadang, although the difficulties associated with investigating this disease prevent results from being obtained within short periods of time.

Much of the expert's program and accomplishments required organization of team work between major departmental entities of the Philippine Government. Through the help of the Honorable Juan de G. Rodriguez, Secretary of Agriculture, arrangements were made whereby cooperation between the Extension Service

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/1. Price, W.C. 1958. Report to the Government of the Philippines on the yellow mottle decline (cadang-cadang) of coconut. FAO Report 850.

and the Bureau of Plant Industry was assured in the active control of cadang-cadang. Special assistance was obtained from representatives of the Bureau of Extension, Mr. Celestino Reantaso and Nicanor Classio, in Lagaspi and Naga City respectively. In this connection, the efforts made by Dr. C. Hart Schaaf, Resident Representative of the Technical Assistance Board of the United Nations and his aids during the initial stage of arrangement are gratefully acknowledged.

Much aid was received from staff members of the University of the Philippines. Visits by interested professors of the University and by technical personnel of the coconut industry have been inspirational to the research group at the Guinobatan Station. Especial thanks are due to Mr. Hans Rothkirk, Assistant Manager, Franklin Baker Company for his continued support of research and his efforts to obtain specific funds for the investigation of the disease.

## II. CURRENT VIEWS ON THE CADANG-CADANG

Before the expert visited the devastated coconut areas of Luzon, the Honorable Juan de G. Rodriguez, Secretary of Agriculture arranged meetings under his personal guidance, to discuss research needed and views on the cause of the disease. The meetings were composed of personnel from the Bureau of Plant Industry, the Bureau of Soils and the College of Agriculture, who had participated in or directed research on the disease. The discussions indicated that those who state cadang-cadang is due to fertilizer deficiencies or to almost total lack of some minor element, were not members of the Bureau of Soils, fertilizer specialists or agronomists, but specialists in other fields. In fact, the opinion that the disease could be a nutrition problem was strongly opposed by members of the Bureau of Soils and by all pathologists except those who had made such claims yet failed completely to substantiate them by field trials. Contrarily, there was no specific proof of any causal agent. The important conclusion from these meetings was that most members of the Philippine Government are favorable to basing research and plans for control on the theory that the causal agent of the disease is probably a virus.

After the expert had the privilege of confering with the personnel of the Guinobatan Experiment Station and had himself visited the devastated areas and newly infected zones, he considered the situation more serious than those who have lived with the disease realized. As the disease has now entered the principal coconut areas of Luzon, he concluded it is such an emergency that research should be streamlined to obtain basic data on etiology and method of spread, and that control along lines that are obviously advisable should be started now before it is too late. The etiological studies should emphasize vectors proved likely by the history of the disease. Control measures should emphasize the presence of thousands of more or less naturally resistant trees within the devastated area that are available for selection and for breeding towards a resistant strain of coconut. Both the Philippine and visiting scientists have pointed out that a resistant variety is necessary irrespective of what the cause may be. Thus initiation of a program for the development of a resistant variety became a principal objective of the expert during his residence in the Islands. The breeding program will be perilously slow unless experimental transmission of the disease is achieved. This fact emphasizes the need for an intensive study of the mode of infection.

Field observations, conferences with more than fifty growers, and the recorded history of the disease prove that the disease is due to an infectious agent and indicate that emphasis of other approaches to solve the etiology is futile. Demonstration of what the agent is and how it spreads remains a principal goal.

## III. NAME OF THE DISEASE AND ITS RELATION TO OTHER COCONUT DISEASES

During the 1958 meeting of the FAO Group on Coconut and Coconut Products in Manila, a technical sub-committee discussed coconut diseases in general but emphasized the Philippine disease. From this discussion, well represented by specialists on coconut problems from many countries, it became apparent that cadang-cadang, often spelled kadang-kadang as that spelling indicates the correct pronunciation, should remain the name of the disease and be adopted internationally. True, names such as "yellow spot decline" would be more descriptive but the established usage of cadang-cadang meaning "dying-dying" dictates continued usage and that name was adopted by the technical sub-committee.

Dr. W.C. Price in his report /2 concluded that the Philippine disease is distinct from those in other countries. Mr. D. Rhind, representative from the United Kingdom, was able to visit the devastated area and see cadang-cadang. He is exceptionally well informed on coconut diseases and has seen most of those present in other parts of the world. From his observations in the devastated area made possible by demonstrations by the staff of the Guinobatan Experiment Station, he was able to state positively that the Philippine disease is distinct.

Since the publication of Dr. Price's report specific information on the wilt disease of coconut palms and the porroca disease have become available. The wilt disease, as described by Nagaraj and Menon /3, present in the Travancore-Cochin area of southern India, is characterized by wilting and by lack of specific spotting of foliage. Early symptoms are a mosaic-like mottling of the very young leaves indicating a virus, as in other mottled monocotoledenous plants, might be the cause. This was verified by successful mechanical transmission with the usual carborundum technique and by transmission by the unusual vector, Stephanitis typicus Dst, the banana lace bug. The facile transmission of the disease and the completely different symptoms readily distinguish this disease from cadang-cadang. The observations of Nagaraj and Menon are significant because they prove for the first time that Cocus nucifera L. is subject to virus infection. The porroca disease affects plants so that they appear superficially like cadang-cadang. The central leaves remain erect in severely diseased plants. According to letters and photographs received from Dr. C. Roland McCully, Research Operations Advisor of the Caja de Crédito Agrario, Industrial y Minero in Colombia where the disease occurs, the porroca disease always causes a speckling of brown decaying fibers in wilted fronds and peculiar white, soft spots within the trunk. No such effects occur in cadang-cadang affected trees and the porroca trouble should be studied as possibly a nematode disease.

All available data indicate cadang-cadang is a distinct disease specific to the Philippines.

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/2. loc. cit.

/3. Magaraj, A.N. and K.P.V. Menon. 1956. Note on the etiology of wilt (root) disease of coconut palms in Travancore-Cochin. Indian Coconut Jour. 2: 161-165.

38/2

## IV. DISTINCTIVE SYMPTOMS OF CADANG-CADANG - CRITICAL DIAGNOSIS

The usual symptoms have been described by the Philippine authors and critically reviewed by Price. The salient effects are: the onset of infection in fruiting trees is first notable from the ground as a discoloration of the 7th or 8th oldest frond and present as a general mottling of the lower fronds. Initial symptoms are followed by a gradual recession of growth evidenced by florescences reduced to 1/3 normal size, similar reduction of fruits, cessation of fruiting, cessation of growth and death within 2 to 10 years. Mr. Carlos A. Calico, who specializes in symptomatology and transmission studies at the Guinobatan Experiment Station, has shown recently that the upper strands of the so called "tertiary feeder roots" breakdown rapidly during the early stages of the disease, this is contrary to previous records of symptoms.

As originally described, and certainly typical of infected trees in locations where the disease is progressively invading, the terminal leaves remain erect and dark green, much greener than the lower spotted leaves. The erect fronds are shaped normally but are slightly shortened. The expert made a comparative study of the constancy of this symptom within a 400 kilometer range extending from the southern tip of Masbate to near the northern end of the affected area in Luzon. In Masbate, where the disease began about ten years ago and extensive devastated areas are not yet present, only the erect green-top form of the disease was observed. In long-invaded areas where most of the trees are dead, one notes many variants of the terminal symptoms, including some in which irregular placement of pinnae produces a frazelled-top appearance. A comparative study of terminal frond variations correlated with variations in the spotting of the older leaves is needed. The gross symptom variations are large and in turn, likely reflect important variations in the causal organism rather than genetically controlled responses of the plant. Such variations are typical of those induced by development of divergent virus strains. The observation that the erect type is dominant in the newly invaded areas and that the variants are conspicuous among the remaining trees in devastated areas, strongly suggests that the variant strain attacks the trees after the type has failed. This circumstance therefore affects the breeding program and makes selection most desirable in devastated areas where some of the remainder have escaped both the type and the variants.

In all forms of the disease a specific spotting precedes degenerative symptoms and remains conspicuous until the plant dies. Irrespective of other symptoms a diseased plant cannot be diagnosed as cadang-cadang except when typical spots are present in their proper sequence. Thus a study of the specificity of the spots was imperative. Initial investigations by Mr. Calico and the expert were made possible by microscope equipment selected for study of living tissues.

The published statements that diseased trees are marked by two kinds of spots, namely yellow and water-soaked, are erroneous. All are dry spots, none are water-soaked, and the reddish coloration of some spots relates to

accidents of pigmentation. If for identification a pin is stuck through a reddish spot and the spot is examined from the other side it becomes macroscopically apparent that there is only one type of spot and that the occasional presence of red pigment led to the fallacy of the water-soaked spot as a second type. The morbid changes wrought in the leaf form little windows that reveal the pigment when present.

The unfolding coconut leaves before they become completely organized for photosynthesis, and during the development of bast fibers and other supporting tissues, engage in unusual metabolic processes evidenced by microscopit entities within subepidermal cells and by epidermal recrements. On the lower surface of fronds one and two, large glands located at intervals of 2 mm. or less within the subepidermal tissues, produce relatively enormous red-colored extrusions. These bodies of stellate form and chitinous-like appearance, are obviously excretion products. As the leaves enlarge and attain position 4, most of the extrusions are rubbed-off. Concurrently with the formation of these extrusions amazing amounts of tannin compounds are formed, and are notably present in the two layers of subepidermal tissue that on both sides of the leaf lie between the epidermis proper and the chlorenchyma. An unidentified red pigment is very abundant in these same cells. The tannins are present in the oxidized "phlobaphene" form and in solution. While the metabolic processes that form tannins are in progress, that is until the fourth leaf stage, the plastids remain very small within the compacted cells of the palisade-chlorenchyma. Thus full development of the photosynthetic apparatus takes place in about the 4th leaf stage and that is where the spot symptoms of cadang-cadang are usually first notable.

By examining directly fresh sections or by treating pieces of leaves with alcohol and extracting the chlorophylls so that the alcohol-insoluble tannin complex and red pigment remain, one notes the high concentration of these metabolic inclusions in the young leaf. There is an irregular distribution of these entities in older leaves and no indication that more are being formed; older leaves are concerned with photosynthesis. It is suggested that the specialized metabolism within young fronds and the lack of well-formed chloroplasts inhibit the formation of cadang-cadang's causal agent and precludes development of typical symptoms until metabolism and cell differentiation are directed specifically towards photosynthesis. These points are here stated with the hope that someone will follow this up with a thorough microchemical study and specifically relate the pH changes in developing tissues to the development of the disease. Additional equipment is needed at the Guinobatan Experiment Station to facilitate such an investigation.

The formation of typical cadang-cadang spots in Cocus nucifera L. relates to necrotic not chlorotic processes. The protoplasts of chlorenchyma cells are transformed by the process known as white-cell necrosis into homogeneous white masses; this accounts for the translucent nature of the spots. In the centers of the spots the epidermal cells are killed and the injured stomata remain slightly open. That observation explains why affected leaves lose water more rapidly than corresponding normal leaves[4]. The subepidermal layers are

4. Recent experiments by Miss Aida S. Barks and Mr. Calica at the Guinobatan Experiment Station indicate that affected leaves lose water 20 percent faster than normal leaves.

little affected and micro-concentrations of red pigment are scattered throughout the leaf. If sufficient pigment remains where a spot is forming then it appears as a red spot. Invading fungi uniformly destroy the pigment, producing spots that are yellow or darkly necrosed. The process of white necrosis continues as long as the leaf is functional, thus accounting for the conspicuous spotting on old leaves. Also the spotting of older leaves is intensified by the effects of more less saprohytic micro-organisms and the general yellowing produced by natural processes of aging.

Such white necrosis is typical of virus infections and may be interpreted as one of the strongest proofs that the disease is due to a virus. That white necrosis is truly the usual symptom of the disease was proved by microscopical examination of the foliage of diseased trees from different parts of the Islands.

## V. SYMPTOMS IN OTHER PALMS

Initial investigation of some of the other palm species obviously cadang-cadang diseased indicated that white necrosis is also connected with their spotting. As the morphology of pinnae of different palm species varies enormously the relation of white (or dark) necrosis to the spotting of other palms cannot be verified except by detailed studies with adequate control materials. A comparative morphological study should be made along with supporting micro and macro-chemical studies.

## VI. A NEW HOST PANDANUS

On 19 March 1959, south of Legaspi above Poliqui Bay, near barrio Cauayan, Mr. Calico and the expert found large plants of Pandanus coplandii Merrill, that were undoubtedly cadang-cadang diseased. The same foliar symptoms and the same distribution of foliar symptoms characteristic of the disease on coconut, were conspicuously present on these large native plants. These plants were growing along a stream within a devastated coconut planting of Mr. Edilberto Arboleda, who is one of the first growers to sign up for the cooperative program. The finding is important for several reasons. Technically it proves a second generic host for the disease and presents an easily grown monocot plant that can be cloned for precise transmission and control studies. The finding of a widely distributed natural host points to the futility of eradication measures as a practical means of control.

## VII. RECENT TRANSMISSION TRIALS AND RECOMMENDATIONS FOR OBTAINING TRANSMISSION

All recent transmission trials were planned to fit the concept that the causal agent must be a virus. The probability of virus etiology is indicated by (1) the absence of other causes, (2) the fact that the pattern of spread is typical of an insect-borne virus, (3) the fact that the morbid anatomy of the distinctive spots is typical of virus infection, and (4) the failure of mechanical transfer from tree to tree. While the gross symptoms are suggestive of a leafhopper-borne virus, they are also, except for the regularity of the sequence in which they are produced, acceptable for a nutritional trouble. Nutritional origin has been disproved by direct experiment and by circumstances: (1) the disease now occurs on more than 46 types of soil, and (2) it has yearly developed in an expanding pattern over an area some 400 kilometers long, not more or less simultaneously as would have occurred were the trees dying from a widely distributed lethal nutritional deficiency but instead, during a period of 40 years, in a fashion characteristic of a slowly spreading disease borne by a slothful insect.

During the expert's residence in the Islands many attempts were made to find an alternate host by using the latest methods applicable to difficult viruses and by selecting likely test plants. Most of the inoculations were made by Mr. Calica during the early morning hours when inactivation of inocula by heat was unlikely. Test plants included the following: maize, (over 4000 plants), abaca (400 plants) and fewer plants of Canna, Commelina species, tobacco varieties; also coconut and the rattan palm, Calamus. Inocula were prepared from the inflorescences, root tips and leaves of diseased trees. No transfer was obtained.

While mechanical transfer from coconut to coconut seems unlikely, some usable test plant may be found. Maize, a bridge plant for many viruses that inhabit monocotyledonous plants, seems most likely, and was thoroughly tested with 4000 plants inoculated by many methods with juice extracts from coconut. Use of maize should be continued and the possibility of buffering or otherwise treating the juice to effect transfer should be tested. Chemicals required for these tests were not available at the Guinobatan Experiment Station during the expert's stay.

Besides the probable low concentration of the virus in most parts of the coconut, two other circumstances explain transfer failures. First, large amounts of tannin compounds are present in parts of coconuts from which inocula have been prepared, and second, the chlorenchyma, the tissue in which virus activity is certainly great, is protected not only by the epidermis but also by two layers of thick-walled cells that function as subepidermises. It is unlikely that the carborundum used in the usual rubbing techniques ever reaches the protected chlorenchyma in which the virus is likely to reproduce. Mr. Calico has made the excellent suggestion that coarse carborundum be tried for coconut to coconut transfers.

Considerable work has been done by Mr. Antonio C. Pizarro to determine the possibility of species of mealy bugs as vectors. In some ways these insects would nicely fit the pattern of spread of the disease.

Approximately 27 species of insects are under test as described by Price. Each species is being tested on 25 plants and each plant has to be grown to an age of at least 3 years, thus requiring many hectares of land for the experiment.

The expert suggested that, rather than feed the insects for a day or so on source plants then cage them on test plants for two weeks or more, it would be preferable to feed the insects for a long time on the source plant and a short time on the test plant. This procedure would insure even pickup of inoculum and avoid insect injury to the test plants that the currently long feeding causes. The extreme height of affected typical Laguna variety of coconut makes the long feeding on source plants difficult to arrange. It was suggested, therefore, that suitable trees be roped and gradually pulled down so they could be readily used. At present Mr. Bigornia has transplanted a small infected tree, burried part of the bole, and built a bamboo structure around the top so that the foliage becomes readily available for long time caging. The insects that survive caging for two weeks on such a tree should be in excellent condition for short time caging on the test plants. With respect to attaining transfer, Mr. Rhind stated that a comparatively large number of insects may be needed on each test plant as the situation may be comparable to that of the swollen shoot disease of cacao. The initial tests with insects as potential vectors should certainly be planned to find the right responsible insect rather than to yield additional data on the requirements for transfer.

## VIII. FURTHER RESEARCHES

A large amount of necessary research is being done on cadang-cadang and other coconut troubles at the Guinobatan Experiment Station. The following suggestions are by no means a criticism of their program but are points which, the expert thinks, should be stressed to obtain basic data for control.

Studies to find a method to transfer the causal agent should be intensified. The same test coconuts should be inoculated by the method under test, insect or mechanical, at least once every two months for a period of at least a year.

Trial of the various chemical tests designed to detect the presence of virus in plants should be thoroughly and carefully performed. This can now be done advantageously by the newly appointed Chemist at the Guinobatan Station. Were it known in what part of the plant virus is most concentrated and available, that information could facilitate the preparation of more effective inocula.

When funds are made available, carefully planned large-scale plantation management experiments should again be attempted. For reasons not understood, methods of plantation management seem to have a direct effect on the incidence of the disease. With the same consideration in mind, the entire region should be surveyed critically to determine why there are less diseased palms in some areas than in others. In this connection, some of the suggestions made by Erquiaga[5] should be given serious consideration.

Some of the work aiming at finding means to increase the economic life of affected plants should be made known soon. This is especially true for trials on gibberellin as initiated by Attorney Jose Mercado, a coconut grower and director of PHILCOA. On the other hand, the staff of the Guinobatan Experiment Station should not be overloaded with new projects, as they must give major attention to the selection program, which combined with breeding, is the only immediate means to save the coconut industry in the Philippines.

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5. Erquiaga, Buenaventura de. 1958. A practical approach to the cadang-cadang problem. Paper read at the Conference on Cadang-cadang held in Legaspi, Albay, 22-24 August 1958 (mimeographed).

## IX. CONTROL PROGRAM

Since a full discussion of the control problem for cadang-cadang has been presented to the Philippine Government and published by the expert[6], only a brief review will be given here.

Most of the research on the disease, and justly so, has been planned to determine the etiology. The only attempts to control were wholesale roguing programs directed to destroy infected trees. The growers consider the eradication program useless; it could even have done harm as the felling of trees may have actually disseminated the vector, even though their tops were burned. Where felling is necessary, as for example diseased trees that are no longer fruiting, treating the tree first with a systemic insecticide would be advisable. It is now apparent that the disease must have a very long incubation period, certainly a year and probably 18 months. During the incubation period, the presence of the disease could not be detected from the ground, yet the tree in which the agent is developing, may be highly infectious. For this reason only ruthless removal of all trees in a locality - healthy coconuts, all other palms and also Pandanus - could possibly have been effective. It is too late to control the disease by eradication now and the long incubation period was not recognized when roguing was practiced. It is now time to start an intensive selection-breeding program to insure eventual control irrespective of the cause.

A selection program has been initiated, and the key point in the program is that all the progeny of a selected source-tree must be identified, in order to permit to some extent genetic analysis of the progeny. Any worth-while selection program should involve thousands of individual plants for comparison. In the case of coconuts which have to be grown to near maturity before judgement is possible, the procedure requires hundreds of hectares of land. Obviously the only practical approach was to invite and insure the participation of growers in the devastated area, where the trees must necessarily be grown and exposed to natural infection.

At the conference on cadang-cadang held in Legaspi on 22 August 1958, Mr. Erquiaga pointed out that the growers must replant irrespective of the disease menace, especially in areas where trees tend to escape, or else the country would soon be out of the coconut business. This view point makes feasible the combining of scientific selection with economic re-planting and his address successfully steered the interest of the growers to such a program. Three discussion meetings, organized and led by the county agents, Messrs Reantaso and Castro, were held in the Bicol area

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6. McWhorter, Frank P. 1959. FAO report on Kadang-kadang, August to December, 1958. Coco Industry Monthly 1 (3-4): 7-14.

with the result that a number of growers expressed interest in the selection program. Special data books were prepared to record the progeny of selected trees on each cooperator's farm. Detailed directions were given for making selections and using the record books. Materials for labelling source trees and selected nuts were provided. The mechanics of the program is arranged, the growers are convinced of its value, and in two years with good follow up on the part of the growers and their advisers, a minimum of ten thousand labelled trees from selected source-trees should be scattered through the area as a first step towards restoring the copra industry in the Bicol region. This program can be implemented at very little expense to the Government, as the personnel at the Guinobatan Station is available for the initial selection work on growers' farms.

A breeding program should be started soon. The same trees used in the selection program will be available for breeding but this procedure will require special financing, additional personnel and probably more land. The expert has suggested that the facilities of FAO be utilized to facilitate the introduction by air of coconut varieties from various countries. Arrangements have been made to plant the introduced nuts on the College of Agriculture campus at Los Banos where they would be isolated as ornamentals scattered over the campus. Mr. Pedro Rodrigo, Horticulturist and Acting Chief, Research Division of the Bureau of Plant Industry, has made the excellent suggestion that the breeding program be initiated and augmented by the introduction of dried pollen of coconuts to be used now, in addition to cross breeding between apparently resistant trees.

The development of practical control for the disease has been hindered by the offer of huge prizes made several years ago for a cure. These offers were made with the best of intentions by individuals who did not realize that this is the type of disease for which a cure is most improbable. Therefore, the expert has included in his previous report[7] a full discussion on the prevention of spread and on the prolonging of the life of affected trees in order to clarify the public thinking. At present any approaches other than selection and breeding, will have to remain at the research level until their value has been demonstrated.

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/7. loc. cit.

## X. CONCLUSIONS AND RECOMMENDATIONS

If practical control measures are not wholeheartedly sponsored now, the Philippines will soon lose their coconut industry. If technical officials undertake immediately work on a large scale with growers in the devastated area, it is very probable that a system of selecting and breeding resistant trees will be found in time to perpetuate the industry. It is entirely possible that when the key to breeding is found, trees that are not only resistant but of better quality may result. Replanting may or may not always prove economically advisable, but some grower should have the satisfaction of having helped save his country's principal agricultural industry.

The recommended measures are as follows:

1. The selection program should be promoted by all interested branches of the Department of Agriculture.

2. A technical officer at the Guinobatan Station should be specifically designated to lead the selection program with the full cooperation of the leaders in the Extension Service in Albay and Camarines Sur.

3. Research on the etiology of the disease should be encouraged and intensified.

4. An adequate survey of cadang-cadang in Pandanus be made to determine what species are naturally infected, their distribution and their relation to the spread of the disease in coconuts.

5. The necessary funds should be provided for carrying out a breeding program under the auspices of the Bureau of Plant Industry field station at Guinobatan.

6. The scientific personnel should encourage the practice of holding discussion meetings with coconut growers, under the auspices of the Bureau of Extension.

*Figure 1.* Pinna of cadang cadang diseased coconut leaf showing distribution of typical white necrotic leaf symptoms. Transmitted light, about 4 x.

*Figure 2.* Pinna of African oil palm *(Elaeis guinensis)*, diseased with cadang cadang. Distribution of white necrosis and chlorotic mottle of typically diseased leaf. Reflected light, approximately 1 x.

*Figure 3.* Leaf of *Pandanus coplanderii* naturally infected with cadang cadang. Note how closely the critical symptoms of *Pandanus coplanderii* resemble those of the African oil palm. This photograph is of a leaf of the naturally infected plant at Banquerohan near Legaspi in southern Luzon. The plant from which this leaf was removed is the type specimen of cadang cadang disease of *Pandanus*. Reflected light, approximately 1 x.

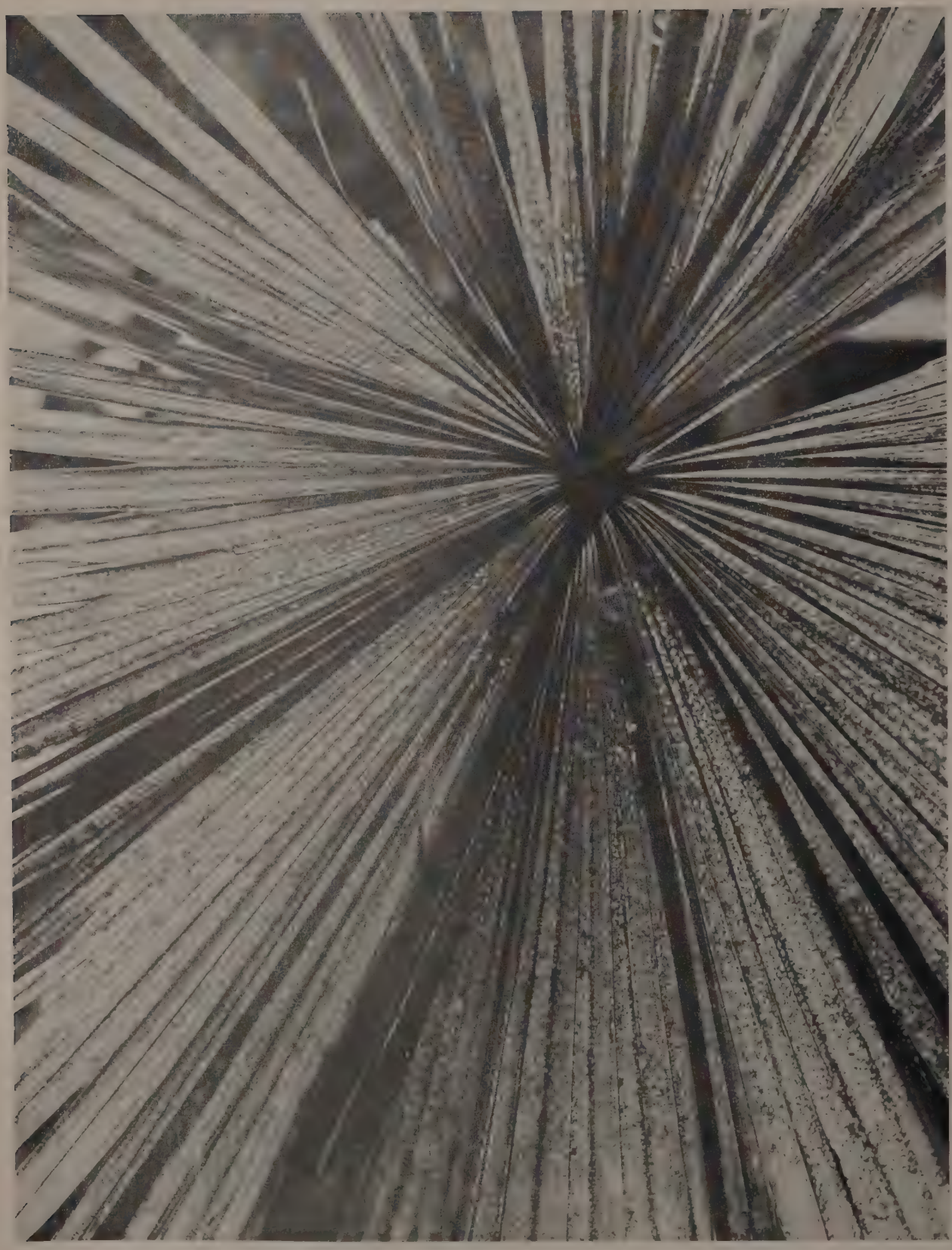

*Figure 4.* Portion of leaf of fan palm (*Livistonia rotundifolia*), diseased with cadang cadang. Note the distribution of the characteristically large spots in the fan palm. Reflected and transmitted light, reduced.

*Figure 5.* Young coconut tree developing significant symptoms of cadang cadang. Photograph to show characteristic distribution of discolorations. Note central leaves remain dark colored. Strong symptoms and yellowing in fully expanded leaves 7, 8, 9, and 10. In this case lowest leaves have the natural coloration for their position on a coconut tree of this age because they were formed prior to development of any symptoms.

*Figure 6.* General appearance of Buri palms *(Corypha alata)* dying from cadang cadang infection.

*Figure 7.* Healthy Buri palm photographed at approximately the same scale as the diseased palm in Figure 6.